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1969

Project Report

EFFECTS OF PINYON-JUNIPER CONVERSION
ON WATERSHED VALUES IN UTAH

Prepared by
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Utah Agricultural Experiment Station
in cooperation with
Bureau of Land Management

April 1, 1969

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Title of Study: "Effects of Pinyon-Juniper Conversion on Watershed Values in Utah"

Objectives:

A. To determine the water budget of natural stands of pinyon-juniper and adjacent areas which have been cleared and/or seeded.

B. To determine the effects of vegetation conversion on soil physical properties and soil stability.

C. To ecologically evaluate sites before and after as to phenology, composition, and production of vegetation.

D. To evaluate the economics of conversion practices in terms of the watershed values and multiple use relations.

E. To obtain data necessary for determination of hydrologic soil cover complexes on the study sites.

Introductory Comment: This report is concerned with additional data analysis and compilation which has resulted since the project report dated January 1, 1969. As before, the report will provide information to supplement previous reports as well as indicate progress to date.

Infiltrometer Studies: Data from the second phase of the two-year study utilizing the Rocky Mountain Infiltrometer on several treated (and nearby untreated) P-J sites in central and southern Utah are still being analyzed. However, some information is now available and is presented below.

METHODS

A Rocky Mountain Infiltrometer (Dortignac, 1951) was utilized to simulate high intensity (three in./hr. or greater) rainfall on plots approximately two and one-half square feet in area. Fourteen treated and nearby untreated

pinyon-juniper sites near Blanding and Milford, Utah were sampled with 325 infiltrometer plots during the summer of 1968. Tables 1 and 2 give a brief description of each site.

The experimental procedures were identical to those already described by the authors (Williams, Gifford, and Coltharp, 1969).

Soils in the study sites were derived from colluvium, alluvium, residuum, and eolian of mainly sedimentary and volcanic rocks (Milford area) and sandstones and shales (Blanding area).

Pinyon-juniper sites near Blanding Utah

Table 3 shows mean infiltration rates (in./hr.) during specified time intervals and Figure 1 denotes relative differences in sediment production from treated and nearby untreated conditions on six pinyon-juniper sites studied near Blanding, Utah. As noted from Table 1, age of treatment varied from 1 to 6 years.

U.S.U. (Utah State University) study site. No significant differences in infiltration rates are indicated between treated and untreated conditions during any time interval on the area double chained with debris in place (item 1, Table 3). However, on the area with debris windrowed, the untreated area showed significantly higher infiltration rates during the time interval 8 to 18 minutes following start of simulated rainfall. There were no significant differences between treated and untreated areas with regard to sediment production.

Area 149, Brush Basin, Peters Point #1, and Peters Point #2. No significant differences between treated and untreated conditions are indicated for either infiltration rates (Table 3) or sediment yields (Figure 1).

Alkali Ridge. At the Alkali Ridge site, the following four exclosures were located within the treated area: (1) everything excluded, (2) rabbits

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Table / . Brief description of study sites near Blanding, Utah.

Project	Location	Date Seeded ^{1/}	Type	Seed lbs/acre	Average Production in 1965 (lbs/acre dry weight)	Elevation ^{2/} (feet)	Annual ^{3/} Precipitation (inches)	Grazing History
1. Pelens Point								
Location #1 ^{4/} chained and debris in place	T32S R23E Sections 14, 15, 22, 23	1964	Crested Wheatgrass	6	Unknown	7,000	14	Negligible summer use before treatment. After treatment light summer use except heavy use around water.
Location #2 chained and debris in place	T32S R23E Sections 31, 32	1960	Crested Wheatgrass	6	Unknown	7,000	14	Same as #1
2. Brush Basin Double chained and debris in place	T35S R22E Sections 20, 29	1962	Crested Wheatgrass	6	Unknown	7,000	16	Before treatment negligible use after treatment stocked at 5ac/AUM.
3. Alkali Ridge Double chained and debris in place	T36S R23E Sections 25, 26, 35, 36	1961	Crested Wheatgrass	6	Unknown	6,000	11-12	Negligible use before treatment, after treat- ment stocked at 4ac/AUM.
4. Job #149 chained and debris in place	T37S R22E Sections 5, 6, 7, 8	1965	Crested Wheatgrass (Four-wing saltbush and yellow sweet- clover)	6 Unknown	Unknown	6,000	11-12	No grazing until 1969.

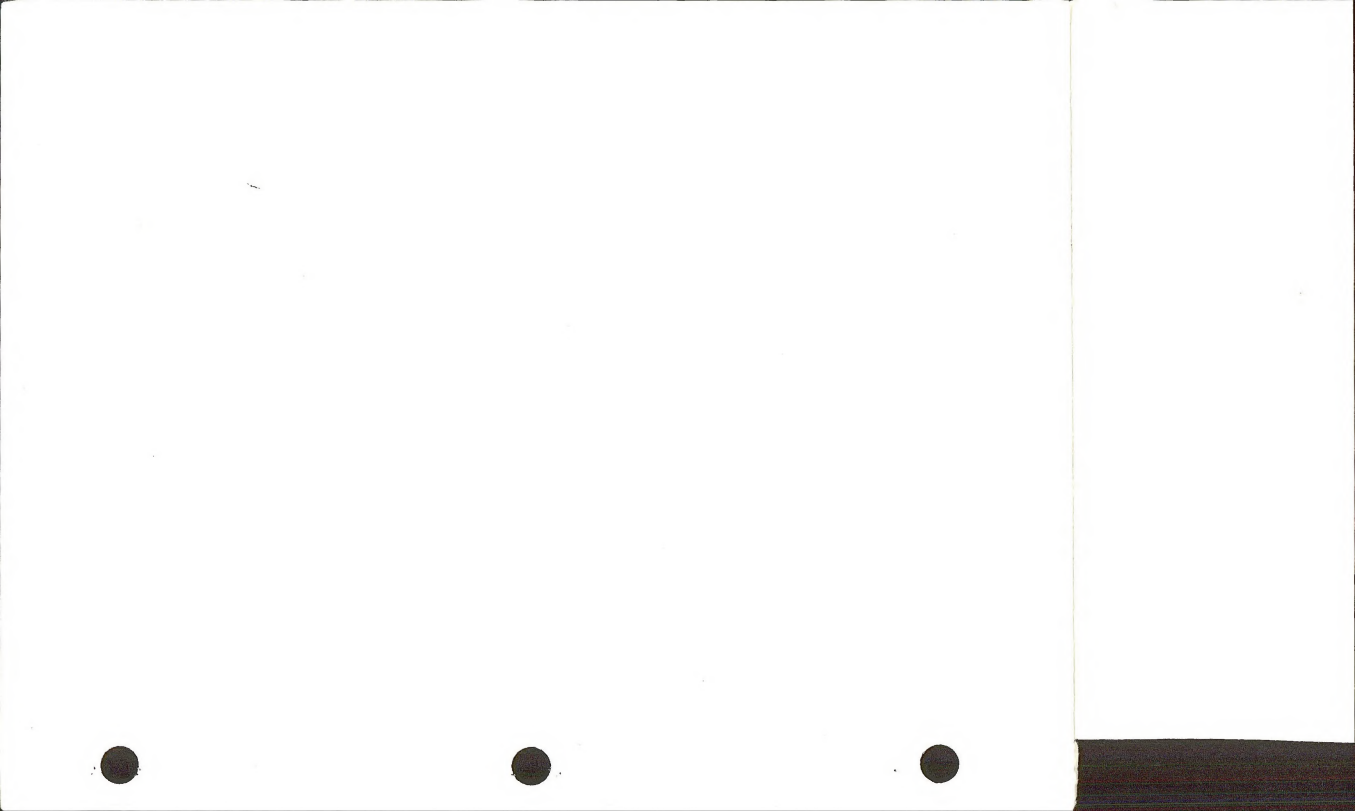


Table / . Continued.

Project	Location	Date Seeded ^{1/}	Seed Type	Seed lbs/acre	Average Production in 1965 (lbs/acre dry weight)	Elevation ^{2/} (feet)	Annual ^{3/} Precipitation (inches)	Grazing History
5. Utah State University Study plots								
Location #1 chained and debris in place	Same	1967	Crested Wheatgrass	6	New job	6,500	11-12	No grazing.
Location #2 chained and windrowed	Same	1967	Same as #1	6	New job	6,500	11-12	No grazing

^{1/} Seeded in fall unless otherwise indicated.

^{2/} Elevations given on all sites weretaken from United States Geological Survey quadrangles (15 minute series)

^{3/} Annual precipitation values taken from the annual normal precipitation map for the State of Utah (1931-1960)

^{4/} Windrowed sites were drill seeded and non windrowed sites were broadcast seeded

Table 2. Brief description of study sites near Milford, Utah.

Project	Location	Date Seeded ^{1/}	Type	Seed lbs/acre	Average Production in 1965 (lbs/acre wet weight)	Elevation ^{2/} (feet)	Annual ^{3/} Precipitation (inches)	Grazing History
1. Indian Peaks								
Location #1 ^{4/} chained and windrowed	T30SR 17W Sections 9, 10	1964	Pubescent Wheatgrass	6	2000	6,500-7,000	10	Grazed in spring, summer and fall before treatment grazed in mid and late summer in rotation system after treatment.
Location #2 chained and windrowed	T30S R17W Section 7 T30S R18W Section 12	1960	Intermediate Wheatgrass	6	3000	6,500-7,000	11	Grazed in spring, summer and fall before treatment grazed in late spring and early summer in a rotation system after treatment.
Location #3 chained and debris in place	T29S R18W Sec 23, 24, 25, 26					6,500-7,000	12	
Location #4 chained and windrowed	T30S R17W Section 27	1961	Pubescent Wheatgrass	6	2000	6,400-6,800	11	Same as #1.
2. New Arrowhead ^{4/} mine. chained and windrowed	T31S R17W Sec 6, 7 T31S R18W Sec 1, 12	1962-64	Intermediate Wheatgrass	6	1,200-1,600	7,500-8,000	15	Before the area was treated grazing use was in conjunction with private land to the west. Very little use because of the heavy trees and lack of feed. The seeding is now used from June 15 to August 31. In 1968 it was used until August 10.

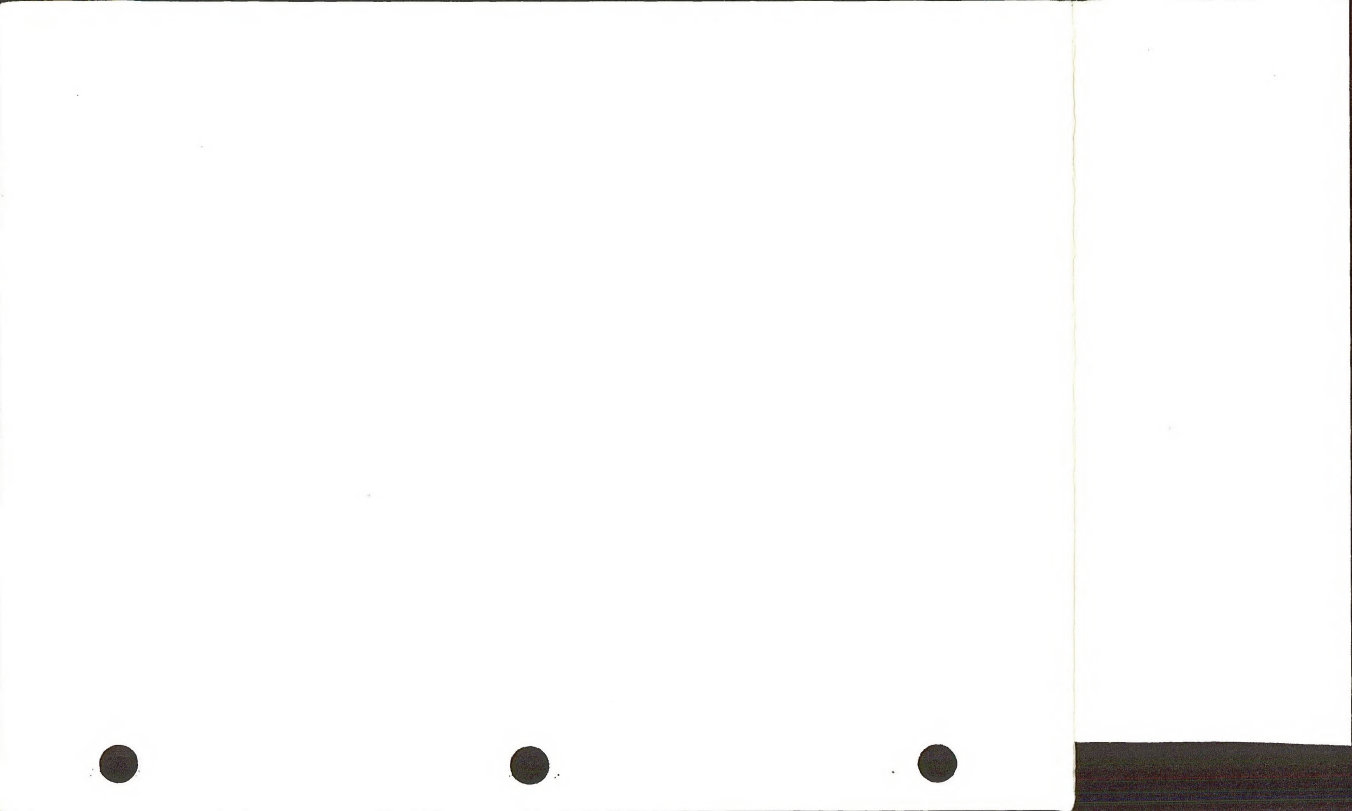


Table 2. Continued.

Project	Location	Date Seeded ^{1/}	Seed Type	lbs/acre	Average Production in 1965 (lbs/acre wet weight)	Elevation ^{2/} (feet)	Annual ^{3/} Precipitation (inches)	Grazing History
3. Jockeys chained and windrowed	T30S R15W Sec 20, 21, 28, 29	1958	Crested Wheatgrass	6	2000	6,500-7,000	12+	Grazed year around before treatment - grazed only in spring and early summer after treatment.
4. Indian Creek Conservation Area chained and windrowed	T28S R7W Sec 26, 27	1959	Crested Wheatgrass	6	2000	6,000-6,500	12	Grazing spring and summer before treatment - after treatment it is grazed in rotation system with few numbers. Cattle are put in when grass is considered ready.
5. Utah State University study sites chained and one-half windrowed and one-half debris in place	T 30S R15W Sec 18, 19 T30S R16W Sec 13, 24	1967	Crested Wheatgrass		New	7,000	12	

^{1/} Seeded in fall unless otherwise indicated

^{2/} Elevations given on all sites were taken from United States Geological Survey quadrangles (15 minute series)

^{3/} Annual precipitation values taken from the annual normal precipitation map for the state of Utah (1931-1960)

^{4/} Windrowed sites were drill seeded and non windrowed sites were broadcast seeded

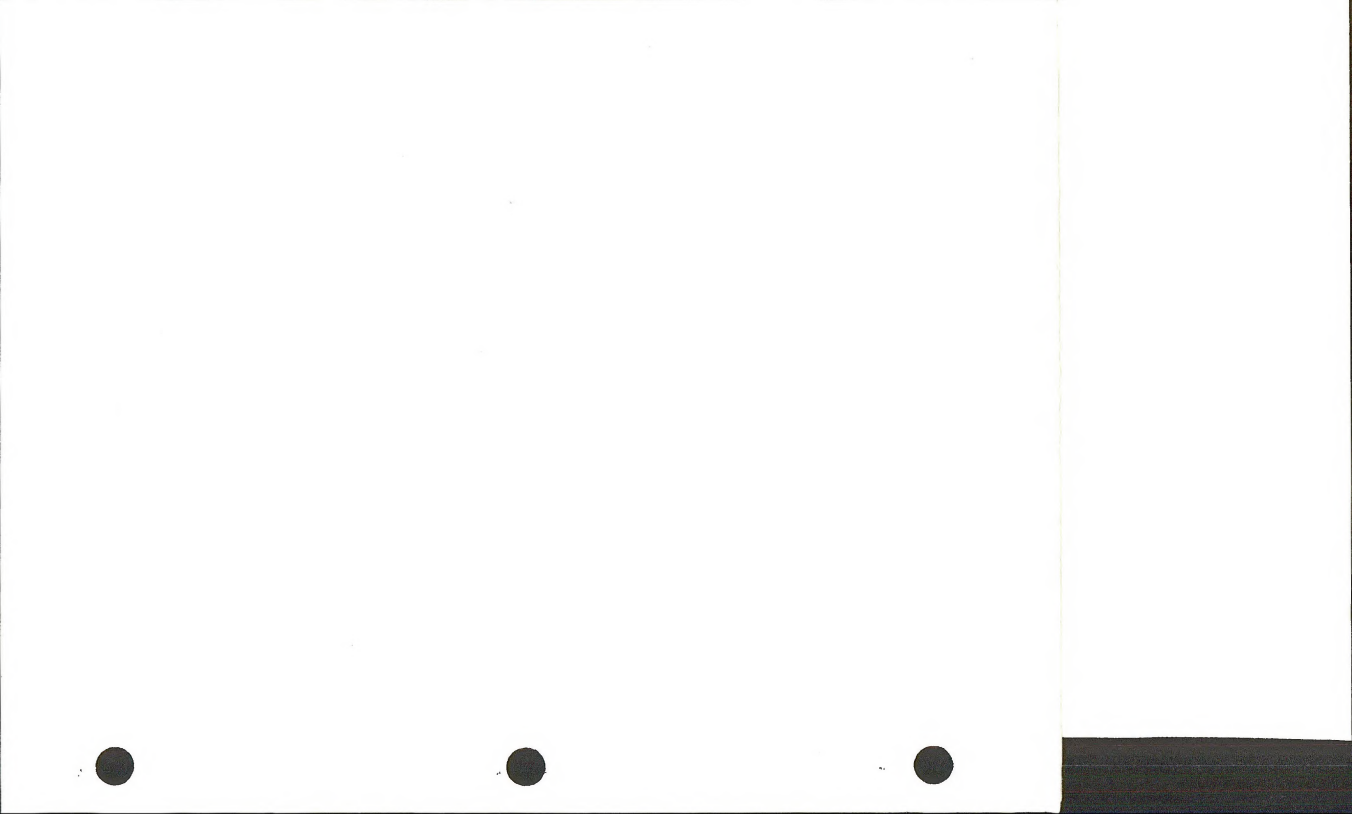


Table 3. Mean infiltration rates (in./hr.) during specified time intervals (minutes) on various pinyon-juniper sites near Blanding, Utah.

Site ^{1/}		3-4	4-5	5-6	6-7	7-8	8-13	13-18	18-23	23-28	28-33	33-38
USU study site (Debris in place)	T U	4.2 3.9	4.0 3.7	3.6 3.9	3.3 3.9	3.4 3.8	3.4 3.4	2.6 3.2	2.4 2.7	2.4 2.6	2.3 2.6	2.3 2.6
USU study site (Debris windrowed)	T U	4.2 3.9	4.2 3.7	4.0 3.9	3.7 3.9	4.0 3.8	3.0 3.4*	2.6 3.2*	2.6 2.7	2.5 2.6	2.5 2.6	2.5 2.6
Area 149	T U	3.2 3.8	3.8 3.9	3.6 3.8	3.1 3.5	3.4 3.4	2.1 2.7	2.1 2.3	2.0 2.2	1.8 2.2	1.8 2.2	1.8 2.2
Brush Basin	T U	3.0 2.7	2.8 2.3	2.6 2.6	2.4 2.3	2.2 2.1	1.8 1.8	1.4 1.5	1.4 1.6	1.4 1.5	1.4 1.5	1.4 1.5
Alkali Ridge (everything except deer excluded)	T U	3.9 3.0	3.8 2.9	3.7 2.9	3.7* 2.7	3.3 3.0	2.9** 1.7	2.4** 1.5	2.3** 1.4	2.2** 1.4	2.2** 1.4	2.2** 1.4
Alkali Ridge (everything excluded)	T U	3.6 3.0	3.6 2.9	3.4 2.9	3.4 2.7	3.5 3.0	2.7* 1.7	2.1* 1.5	1.9* 1.4	1.7 1.4	1.8 1.4	1.8 1.4
Alkali Ridge (Including cattle)	T U	3.3 3.0	3.1 2.9	3.0 2.9	3.0 2.7	2.9 3.0	2.3* 1.7	2.0* 1.5	1.9* 1.4	1.9* 1.4	1.8* 1.4	1.8* 1.4
Alkali Ridge (excluding every- thing except deer and rabbits)	T U	3.4 3.0	3.4 2.9	3.4 2.9	3.1 2.7	3.0 3.0	2.4 1.7	2.1 1.5	2.1* 1.4	2.0 1.4	2.0 1.4	1.9 1.4



Table 3. Continued.

Site ^{1/}		3-4	4-5	5-6	6-7	7-8	8-13	13-18	18-23	23-28	28-33	33-38
Alkali Ridge (excluding every- thing except rabbits)	T	3.7	3.8	3.6	3.1	2.8	2.0	1.6	1.5	1.5	1.5	1.5
	U	3.0	2.9	2.9	2.7	3.0	1.7	1.5	1.4	1.4	1.4	1.4
Peters Point #1	T	4.0	3.6	2.6	2.7	2.4	1.5	1.4	1.4	1.4	1.4	1.4
	U	4.6	3.4	3.0	3.0	2.7	1.8	1.6	1.6	1.5	1.5	1.5
Peters Point #2	T	4.0	3.6	3.4	2.8	2.7	1.9	1.8	1.7	1.6	1.6	1.6
	U	4.6	3.4	3.0	3.0	2.7	1.8	1.5	1.6	1.5	1.5	1.5

^{1/} See Table 1 for a brief description of sites.

* Significantly larger at 5% than other value in pair.

** Significantly larger at 1% than other value in pair.

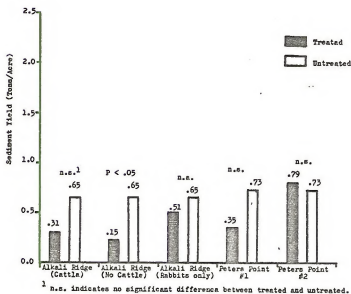
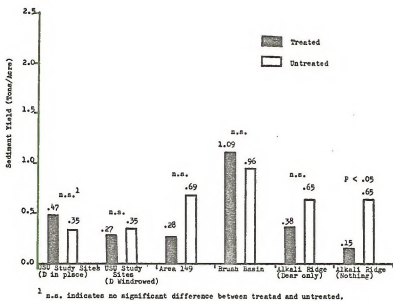


Fig. 1. Sediment yield from six P-J sites near Blanding, Utah.



only, (3) deer only, and (4) deer and rabbits only. As noted in Table 3, infiltration rates were significantly greater after approximately 6 minutes of simulated rainfall in the deer only enclosure and on the treated area (outside enclosures) after 8 minutes. Similarly, in the enclosure excluding everything, a significantly higher infiltration rate was observed during the 8 to 23 minutes time interval. A significantly higher infiltration rate is indicated for the deer and rabbit only enclosure during the time interval between 18 and 23 minutes. No significant differences were noted in infiltration rates between treated and untreated conditions pertaining to the rabbits only enclosure.

As noted in Figure 1, sediment yields are significantly greater from untreated conditions than from the deer and rabbits only enclosure and the everything excluded enclosure. No significant differences are signified between any other treated or untreated conditions.

Pinyon-juniper sites near Milford, Utah

Table 4 shows mean infiltration rates during specified time intervals and Figure 2 denotes relative differences in sediment production from treated and untreated conditions on eight sites near Milford, Utah.

Arrowhead Mine and Indian Peaks #1, 2, 3, and 4. As noted in Table 4 the infiltration rate during the 3 to 4 minute time interval on Indian Peaks #1 site was significantly greater on the untreated area. No significant differences in infiltration rates between treated and untreated conditions were demonstrated for any other time intervals on Indian Peaks numbers 1, 2, 3, and 4, or Arrowhead Mine. Also, as noted in Figure 2, there were no significant differences between treated and untreated conditions with respect to sediment production on any of the above areas.

U.S.U. study site. No significant differences in infiltration rates are

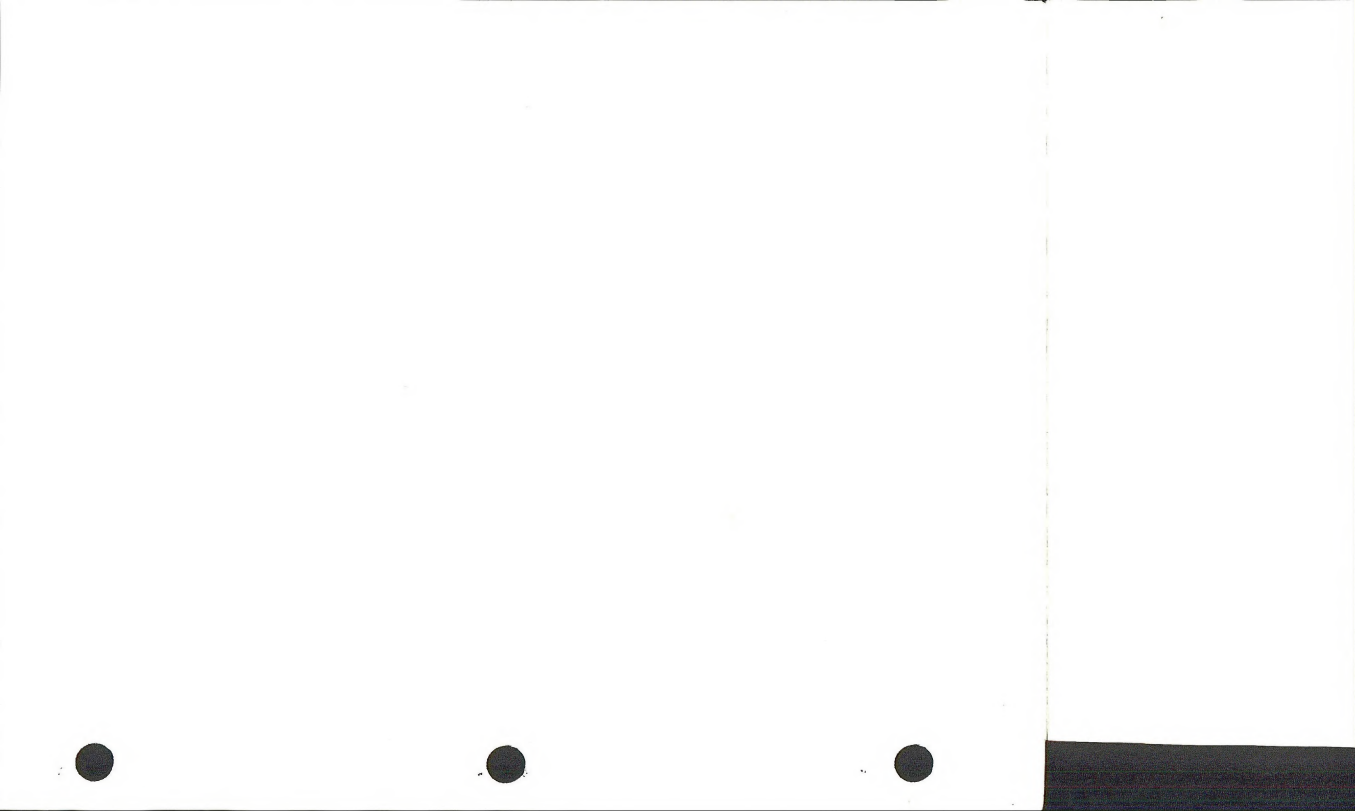
Table 4. Mean infiltration rates (in./hr.) during specified time intervals (minutes) on various pinyon-juniper sites near Milford, Utah.

Site ^{1/}		3-4	4-5	5-6	6-7	7-8	8-13	13-18	18-23	23-28	28-33	33-38
Indian Peaks #1	T	3.1	2.5	2.3	2.2	2.0	1.7	1.6	1.5	1.5	1.5	1.5
	U	3.9*	3.2	2.7	2.2	2.2	1.8	1.7	1.6	1.6	1.7	1.7
Indian Peaks #2	T	3.6	2.6	2.2	1.9	2.0	1.8	1.7	1.6	1.6	1.6	1.6
	U	4.0	3.3	2.8	2.3	1.2	1.8	1.8	1.7	1.7	1.7	1.7
Indian Peaks #3	T	4.2	3.9	4.8	4.4	4.3	3.9	3.8	3.7	3.9	3.9	3.9
	U	5.4	4.9	5.1	4.9	4.7	4.2	4.0	3.9	4.0	4.0	4.0
Indian Peaks #4	T	3.2	2.4	3.2	2.6	2.5	1.8	1.4	1.3	1.3	1.3	1.3
	U	4.0	3.4	3.1	2.6	2.7	2.5	2.3	2.1	2.1	2.1	2.1
Jockeys	T	4.1**	4.1**	3.0**	3.2**	3.0**	2.9**	2.8**	2.7**	2.8**	2.9**	2.9**
	U	2.0	1.8	1.7	1.5	1.6	1.3	1.0	1.0	1.0	1.0	1.0
USU study site (Debris in place)	T	3.1	2.6	2.5	2.2	2.2	1.6	1.6	1.5	1.5	1.4	1.4
	U	3.5	3.0	2.9	2.7	2.7	2.2	2.1	2.1	2.0	2.0	2.0
USU study site (Windrowed)	T	2.6	2.4	2.4	2.3	2.2	1.8	1.4	1.5	1.5	1.5	1.5
	U	3.5	3.0	2.9	2.7	2.7	2.2	2.1*	2.0*	2.0*	2.0	2.0
Indian Creek	T	3.8	3.1	2.6	2.2	2.1	1.6	1.3	1.2	1.3	1.2	1.2
	U	3.8	3.7	3.7*	3.0	3.0	2.6*	2.2*	2.0*	2.0*	2.0*	2.0*
Arrowhead Mine	T	4.0	4.0	3.2	3.0	2.7	2.8	2.6	2.5	2.5	2.5	2.5
	U	3.6	3.6	3.5	3.1	3.7	2.7	2.6	2.3	2.4	2.3	2.3

^{1/} See Table 2 for a brief description of sites.

* Significantly larger at 5% level than other value in pair.

** Significantly larger at 1% level than other value in pair.



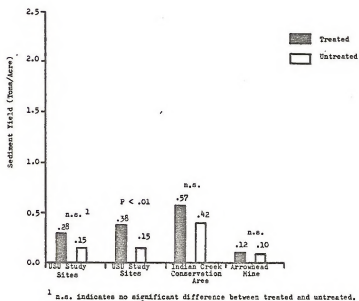
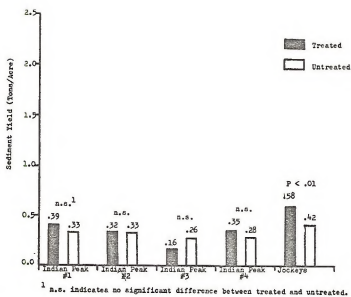


Fig. 2. Sediment yield from eight P-J sites near Milford, Utah.



shown (Table 4) between the double chain with debris in place treatment and the untreated area. The area with debris windrowed shows a significantly lower infiltration rate during the time interval 13 to 28 minutes following start of simulated rainfall. No significant differences in sediment yields occurred on either area.

Jockey's. The treated area shows significantly higher infiltration rates for all time intervals during simulated rainfall. Also, and somewhat unexpectedly, a significantly higher sediment yield is shown for the treated condition.

Beaver. In contrast to the Jockey's area, the untreated area shows significantly higher infiltration rates during the 5 to 6 minute time interval and all time intervals after 8 minutes of simulated rainfall. No significant differences in sediment yields are apparent between treated and untreated conditions.

SOME TENTATIVE CONCLUSIONS

Infiltration and sediment data collected with a Rocky Mountain infiltrometer on 14 sites in southern Utah indicate that areas cleared of pinyon-juniper trees and seeded to grass show no consistent decrease or increase in sediment yields or infiltration rates at a given point. Of 14 sites studied, three indicated decreased infiltration rates on the treated portion and two sites indicated increased infiltration rates on the treated area. Nine sites showed no significant differences in infiltration rates between the treated and untreated conditions. As for sediment yields, one site had significantly less sediment yield from the treated area and two sites had significantly higher sediment yields from the treated areas.

These findings are similar to the results recently reported from study of

14 sites in central Utah by the authors. After study of 28 sites (approximately 550 infiltrometer plots) involving pinyon-juniper conversion practices and associated point changes in watershed values, it may be concluded that infiltration and erosion rates at a given point are not particularly affected as a result of treatment practices. If there is an effect, it may be either positive or negative.

It is well known that many biotic, edaphic and climatic variables interact to determine infiltration and erosion rates at a point on given landscapes. All of the above data will be further analyzed to determine those factors important in determining or predicting infiltration rates and sediment yields on each infiltrometer plot. Such analyses should aid in future predictions of the effect that certain vegetation conversion practices have on watershed parameters.

Future infiltrometer studies should concentrate on seasonal variations in infiltration and sediment production rates as well as the effect of antecedent moisture conditions, varied rainfall intensities, and grazing (and particularly trampling) on such values.

Soil Studies. A copy of the manuscript entitled "Influence of Pinyon-Juniper Conversions and Water Quality on Permeability of Surface Soils" is to be found in the Appendix B. The paper is scheduled for publication in the August issue of Water Resources Research.

Runoff Plot Studies, Blanding Area. Data from the storm of 7-28-68 (see Table 1, January 1, 1969 Project Report) was not included in the January 1 report. Table 5 gives runoff values for the chain and windrow treatment and control on a paired plot basis. Mean runoff from the chain and windrow treatment was 0.07 area inches compared with 0.02 area inches from the control plots. The

Table 5. Runoff data (area inches) from Blanding chain and windrow plots (0.11 acre) and control plots for storm of 7-28-68 (0.45 inches total precipitation).

Plot No.	Treatment		Difference $D = X_1 - X_2$	Deviation $d = D - \bar{d}$	Squared Deviation d^2
	Windrow X_1	Control X_2			
1	.02	.01	+.01	-.04	.0016
2	.16	.05	+.11	+.06	.0036
3	.02	.01	+.01	-.04	.0016
4	.13	.01	+.12	+.07	.0049
5	<u>.02</u>	<u>.01</u>	<u>+.01</u>	-.04	<u>.0016</u>
Total	.35	.09	.26		.0133
Mean	.07	.02	$\bar{d} = .05$		

$$S_D^2 = \frac{.0133}{4} = .0033$$

$$S_D = \sqrt{.0033} = .057$$

$$S_{\bar{d}} = \frac{.057}{2.24} = .025$$

$$t = \frac{.05 - 0}{.025} = 2.0 \quad (.20 > p > .10)$$

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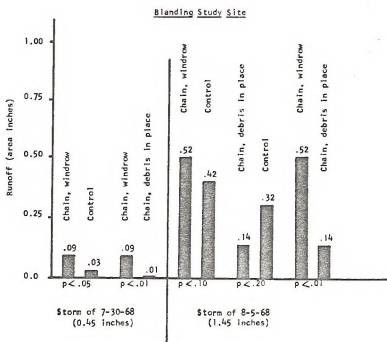
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difference is significant at the .20 level of probability. There was no measurable sediment.

There was no measurable sediment or runoff from the double chaining with debris in place treatment for the 7-28-68 storm.

Runoff Plot Studies, Milford Area. Several runoff-producing storms occurred at the Milford site during the summer, but only those plots which were completed at the time of a storm provided runoff and sediment data. Runoff data has been analyzed for the storms of 7-30-68, 7-31-68 and 8-8-68 for the chain and windrow runoff plots only. Runoff plots in the double chaining with debris in place treatment were not completed until mid-August and therefore, runoff data from these plots are fragmentary. Respective controls were not yet installed either, so such data are omitted here. No runoff events occurred after 8-8-68.

Precipitation records. Table 6 given rainfall data through October 3 when runoff recorders were shut down.

Storm of 7-30-68. Table 7 gives runoff values for the chain and windrow treatment and control on a paired plot basis. Mean runoff was 1.27 area inches from the chain and windrow treatment plots compared with 0.77 area inches from the control plots. The difference is significant at the .10 level of probability.

It may appear that runoff is unusually high from at least three of the runoff plots in the chain with windrow treatment. However, it should be noted that the storm was of fairly high intensity throughout the duration of most of the rainfall. In addition, surface soils were very moist due to cloudy conditions and rain which had fallen on each of the preceeding eight or nine days. Such conditions would promote high runoff rates.

Sediment records were not good due to sampling problems.

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Table 6. Precipitation data from Milford pinyon-juniper study site.

Date	Time Storm Began (MST)	Total Rainfall (inches)	Average Intensity (in/hr.)
7-8-68	Rainfall records started		
7-21-68	6:30 p.m.	0.05	----
7-22-68	12:30 p.m.	0.15	----
7-23-68	2:30 a.m.	0.10	----
7-23-68	9:00 p.m.	0.10	----
7-23-68	11:00 p.m.	0.30	0.30
7-24-68	10:30 a.m.	0.05	----
7-25-68	10:30 a.m.	0.55	0.55
7-27-68	9:00 p.m.	0.15	----
7-28-68	1:30 a.m.	0.05	----
7-29-68	10:30 a.m.	0.05	----
7-30-68	3:30 p.m.	1.65	2.40 (based on first 1.50" of rainfall)
7-31-68	12:15 p.m.	0.60	0.80 (based on first 0.40" of rainfall)
8-2-68	9:00 a.m.	0.10	----
8-2-68	4:00 p.m.	0.10	----
8-5-68	1:00 p.m.	0.05	----
8-8-68	1:15 p.m.	0.70	0.15
8-10-68	5:30 p.m.	0.10	----
8-13-68	12:30 p.m.	0.20	----
8-22-68	4:00 a.m.	0.15	----
9-4-68	1:30 p.m.	0.10	----
9-29-68	2:30 a.m.	0.15	----
10-3-68	Storage gage charged - recording gages shut down		

Table 7. Runoff data (area inches) from Milford chain and windrow plots (0.11 acre) and control plots for storm of 7-30-68 (1.65 inches total precipitation).

Plot No.	Treatment		Difference $D = X_1 - X_2$	Deviation $d = D - \bar{d}$	Squared Deviation d^2
	Windrow X_1	Control X_2			
1	1.51	0.35	+1.16	+0.66	.4356
2	1.53	1.21	+0.32	-0.18	.0324
3	1.45	1.40	+0.05	-0.45	.2025
4	0.72	0.54	+0.18	-0.32	.1024
5	<u>1.15</u>	<u>0.35</u>	<u>+0.80</u>	+0.30	<u>.0900</u>
Total	6.36	3.85	+2.51		.8629
Mean	1.27	0.77	$\bar{d} = 0.50$		

$$S_D^2 = \frac{.8629}{4} = .2157$$

$$S_D = \sqrt{.2157} = .46$$

$$S_{\bar{d}} = \frac{.46}{2.24} = .205$$

$$t = \frac{.50 - 0}{.205} = 2.44 \quad (.10 > p > .05)$$

Storm of 7-31-68. Table 8 shows a mean runoff of 0.19 area inches from chain and windrow treatment compared with 0.12 area inches from control plots. The difference is significant at the .20 level of probability.

Sediment records were not good due to sampling problems.

Storm of 8-8-68. Table 9 shows a mean runoff of 0.07 area inches from chain and windrow plots as compared with 0.02 area inches from control plots. The difference is significant at the .20 level of probability.

There were no measurable sediment yields.

Additional Comments. Line intercept data concerning tree, shrub and ground cover of the Milford runoff plots are given in Table 10. Blanding runoff plot cover characteristics will be forthcoming in the next report.

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Table 8. Runoff data (area inches) from Milford chain and windrow plots and control runoff plots for storm of 7-31-68 (0.60 inches total precipitation).

Plot No.	Treatment		Difference $D = X_1 - X_2$	Deviation $d = D - \bar{d}$	Squared Deviation d^2
	Windrow X_1	Control X_2			
1	.30	.09	+ .21	+0.14	.0196
2	.39	.29	+ .10	+0.03	.0009
3	.13	.08	+ .05	-0.02	.0004
4	.05	.11	- .06	+0.01	.0001
5	<u>.09</u>	<u>.05</u>	<u>+ .04</u>	-0.03	<u>.0009</u>
Total	0.96	0.62	+0.34		.0219
Mean	0.19	0.12	$\bar{d} = 0.07$		

$$s_D^2 = \frac{.0219}{4} = .0055$$

$$s_D = \sqrt{.0055} = .074$$

$$s_{\bar{d}} = \frac{.074}{2.24} = .033$$

$$t = \frac{.07 - 0}{.033} = 2.12 \quad (.20 > p > .10)$$

Table 9. Runoff data (area inches) from Milford chain and windrow plots (0.11 acres) and control plots for storm of 8-8-68 (0.70 inches total precipitation).

Plot No.	Treatment		Difference $D = X_1 - X_2$	Deviation $d = D - \bar{d}$	Squared Deviation d^2
	Windrow X_1	Control X_2			
1	0.15	0.06	+0.09	+0.04	.0016
2	0.17	0.05	+0.12	+0.07	.0049
3	0.02	0.01	+0.01	-0.04	.0016
4	0.02	0.00	+0.02	-0.03	.0009
5	<u>0.00</u>	<u>0.00</u>	<u>0.00</u>	-0.05	<u>.0025</u>
Total	0.36	0.12	0.24		.0115
Mean	0.07	0.02	$\bar{d} = 0.05$		

$$s_D^2 = \frac{.0115}{4} = .0029$$

$$s_D = \sqrt{.0029} = .054$$

$$s_{\bar{d}} = \frac{.054}{2.24} = .024$$

$$t = \frac{.05 - 0}{.024} = 2.08 \quad (.20 > p > .10)$$

Table 10. Tree shrub and ground cover (percent) on runoff plots at the Milford study site, September, 1968.

Plot	Transect Number ^{1/}	Percent Cover			
		Tree	Shrub		Ground ^{2/}
Windrow # 1	1 19 ft.	0.00	0.00	P	90.25
				Agcr	2.28
				L	0.57
				Phho	0.19
				R	2.66
				BG	4.05
	2 33 ft.	0.00	0.00	P	79.80
				Agcr	0.57
				L	3.80
				Phho	0.19
				R	8.30
				BG	7.34
	3 74 ft.	0.00	0.00	P	91.01
				Agcr	0.57
				L	4.75
				BG	3.67
	$\bar{x}$	0.00	0.00	P	87.02 ✓
				Agcr	1.14 ✓
				L	3.04 ✓
				Phho	0.13
				R	3.65
				BG	5.02 ✓
Windrow # 2	1 19 ft.	0.00	0.00	P	3.00
				Agcr	2.20
				L	5.00
				Annuals	0.60
				R	0.20
				BG	88.40
				Lupine spp.	0.60
	2 33 ft.	0.00	0.00	P	0.00
				Agcr	0.41
				L	19.98
				Annuals	0.41
				R	0.41
				BG	77.57
				Phho	0.61
				Misc.	0.61

^{1/} Line Transects across runoff plots at indicated distances measured from top of plot.

^{2/} P = pavement R = rock
L = litter BG = bare ground

Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover			
		Tree	Shrub		Ground ^{2/}
	3 74 ft.	0.00	0.00	P Ager L BG Annuals R	0.00 0.67 14.69 83.75 0.22 0.67
$\bar{x}$		0.00	0.00	P Ager L BG Annuals Phho R Lupine spp. Misc.	1.00 1.09 13.22 83.48 0.41 0.20 0.20 0.20 0.20
Windrow # 3	1 19 ft.	0.00	0.00	P Ager L BG Lupine spp.	37.82 1.53 2.88 56.81 0.96
	2 33 ft.	0.00	0.00	P Ager L BG Lupine spp. R	13.05 1.34 4.60 78.71 2.11 0.19
	3 74 ft.	0.00	0.00	P Ager L BG Lupine spp. R Annuals	0.00 1.71 0.95 94.49 2.47 0.19 0.19
$\bar{x}$		0.00	0.00	P Ager L BG Lupine spp. R Annuals	16.96 1.53 2.81 76.66 1.85 0.13 0.06

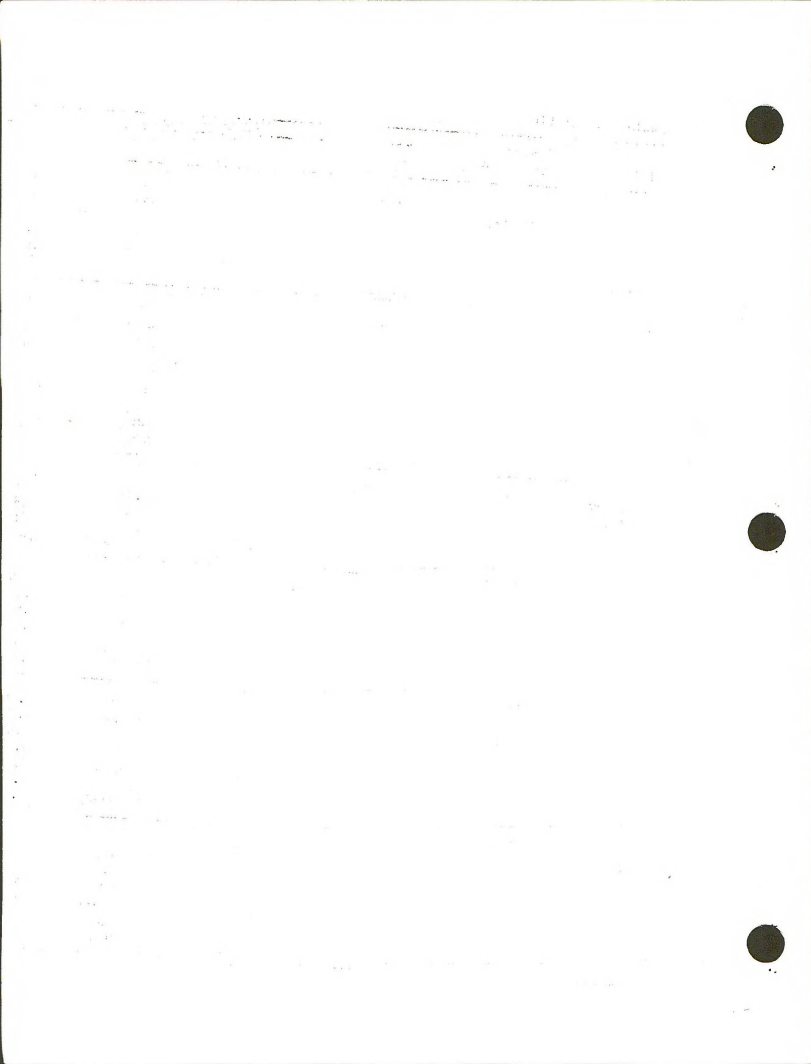


Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover			Ground ^{2/}			
		Tree	Shrub					
Windrow # 4	1 19 ft.	0.00	0.00	P	95.21			
				Agcr	1.92			
				L	2.68			
				BG	0.00			
				Annuals	0.19			
	2 33 ft.	0.00	0.00	P	88.32			
				Agcr	0.76			
				L	7.87			
				BG	3.05			
				3 74 ft.	0.00	0.00	P	45.12
	Agcr	1.97						
	L	3.27						
	BG	48.69						
	Ann C	0.19						
	Penst. spp.	0.38						
	Rock	0.38						
x	0.00	0.00	P	76.22				
			Agcr	1.55				
			L	4.61				
			BG	17.23				
			Ann	0.13				
			Penst. spp.	0.13				
			Rock	0.13				
			Windrow # 5	1 19 ft.	0.00	0.00	P	0.00
							Agcr	0.57
							L	2.68
BG	93.88							
Lupine spp.	0.38							
2 33 ft.	0.00	0.00		R	2.49			
				P	0.00			
				Agcr	1.15			
				L	0.38			
				BG	96.55			
3 74 ft.	0.00	0.00		R	1.92			
				P	0.00			
				Agcr	1.53			
				L	0.76			
			BG	92.15				
Annuals	0.19	5.37						

Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover			
		Tree	Shrub	Ground ^{2/}	
$\bar{x}$		0.00	0.00	P	0.00
				Agcr	1.08
				L	1.27
				BG	94.20
				Annuals	0.06
				R	3.26
				Lupine spp.	0.13
Windrow Check # 1	1 19 ft.	Juos 29.38	0.00	P	43.50
				L	50.19
				BG	5.74
				Lupine spp.	0.19
				Opuntia	0.19
				Phho	0.19
	2 33 ft.	Juos 12.16	0.00	P	62.16
				L	34.79
				BG	2.86
				Annuals	0.19
	3 74 ft.	0.00	0.00	P	83.58
				L	13.20
				BG	2.86
				Sihiy	0.18
				Chvi	0.18
$\bar{x}$		Juos 13.85	0.00	P	63.08
				L	32.73
				BG	3.89
				Annuals	0.06
				Opuntia	0.06
				Phho	0.06
				Sihiy	0.06
				Chvi	0.06
Windrow Check # 2	1 19 ft	Pimo 17.24 Juos 4.26	Artr 0.19	P	25.77
				L	61.24
				BG	0.19
				R	12.80
	2 33 ft.	Pimo 8.84 Juos 15.71	0.00	P	25.73
				L	67.19
				BG	6.50
				R	0.58

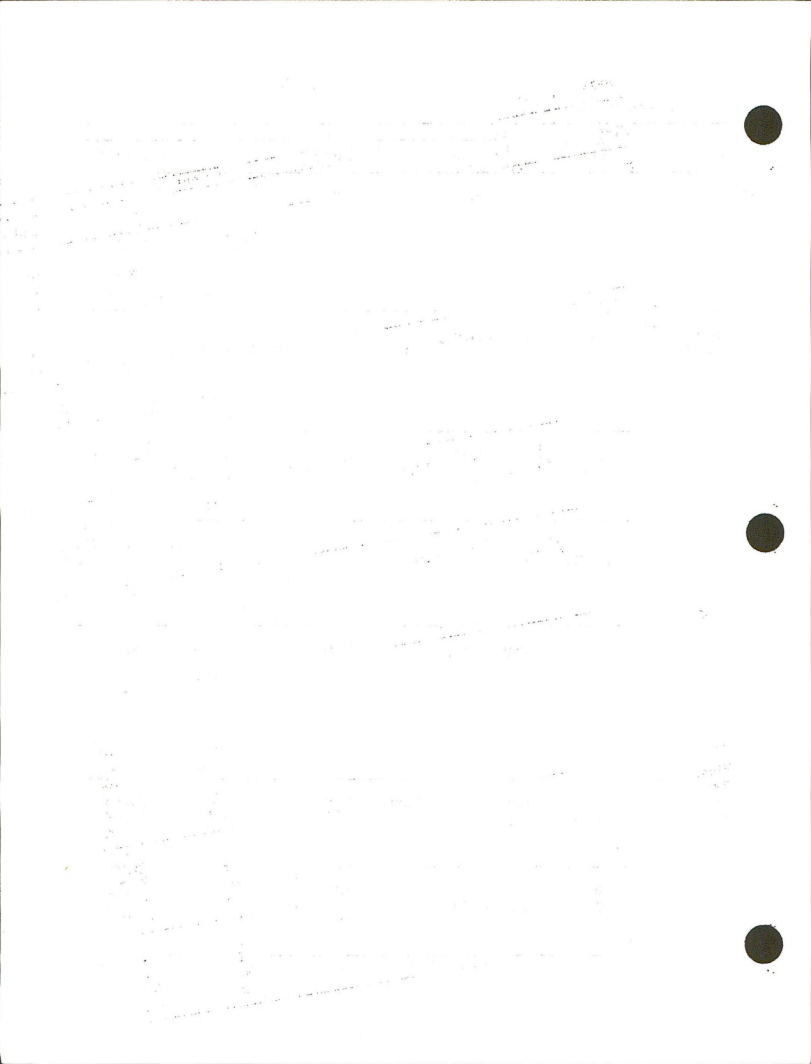


Table 10. Continued.

Plot	Transect Number $\frac{1}{2}$	Percent Cover					
		Tree		Shrub		Ground $\frac{2}{2}$	
	3 74 ft.	Pimo	1.16	Artr	3.68	P	21.14
		Juos	29.87			L	50.82
						BG	27.85
						R	0.19
$\bar{x}$		Pimo	9.08	Artr	1.29	P	24.21
		Juos	16.61			L	59.75
						BG	11.51
						R	4.53
Windrow Check # 3	1 19 ft.	Juos	40.28	Artr	0.95	P	3.80
						L	22.42
						BG	72.64
						Phho	1.14
	2 33 ft.	Juos	6.65		0.00	P	40.85
		Pimo	45.03			L	43.89
						BG	15.26
	3 74 ft.	Juos	47.31		0.00	P	5.70
						L	34.77
						BG	57.06
						R	0.38
						Chvi	2.09
	$\bar{x}$	Juos	31.41	Artr	0.32	P	16.78
		Pimo	15.01			L	33.69
						BG	48.33
						R	0.13
						Phho	0.38
Windrow Check # 4	1 19 ft.	Pied	3.04	Artr	3.80	P	55.29
		Juos	7.03			L	18.24
						BG	26.09
						R	0.38
	2 33 ft.	Pimo	15.70	Artr	1.33	P	56.43
		Juos	7.98			L	35.72
						BG	7.85
	3 74 ft.	Juos	15.39	Artr	5.32	P	30.97
		Pied	37.62			L	60.61
						BG	8.42

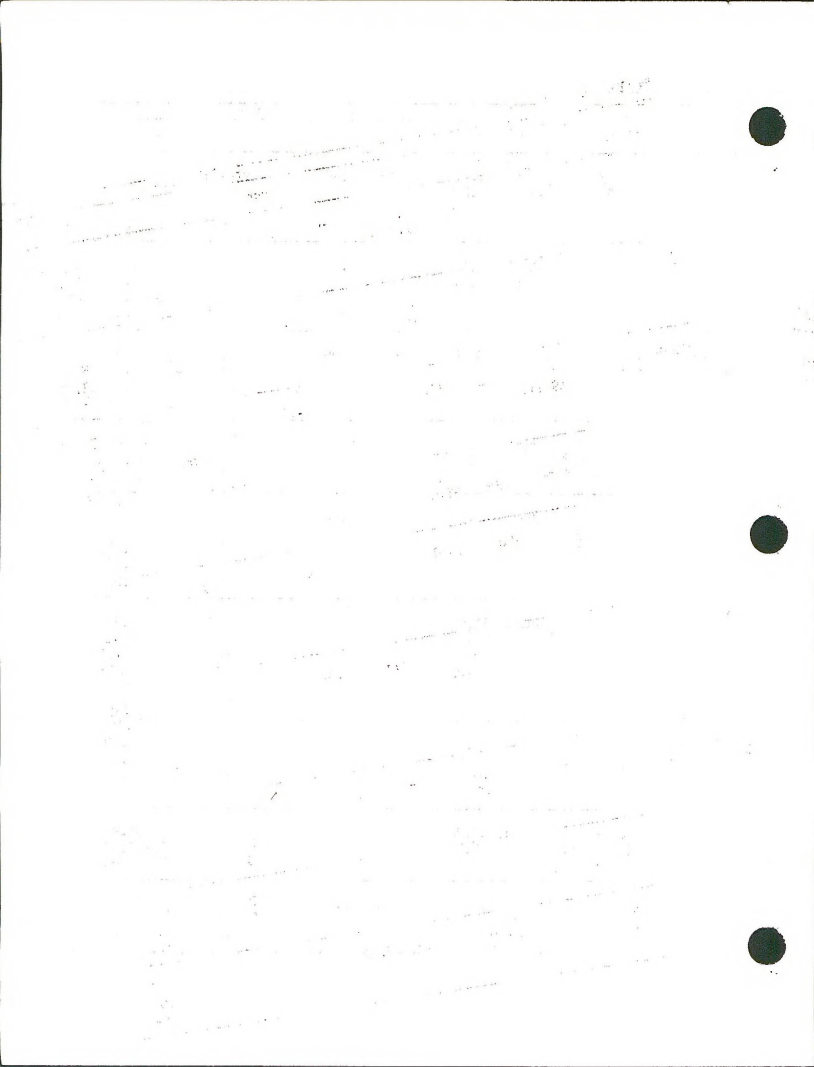


Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover					
		Tree		Shrub		Ground ^{2/}	
$\bar{x}$		Pied	18.79	Artr	3.48	P	47.56
		Juos	10.13			L	38.19
						BG	14.12
						R	0.13
Windrow Check # 5	1 19 ft.	Pied	34.77		0.00	P	42.75
						L	45.60
						BG	11.46
						Opuntia	0.19
	2 33 ft.	Pied	34.20		0.00	P	48.64
		Juos	6.08			L	49.97
						BG	0.63
						Opuntia	0.76
	3 74 ft.	Juos	23.75	Artr	4.56	P	55.48
						L	41.61
						BG	2.15
						Phho	0.76
$\bar{x}$		Pied	22.99	Artr	1.52	P	48.96
		Juos	9.94			L	45.73
						BG	4.74
						Opuntia	0.32
						Phho	0.25
Debris Check # 1	1 19 ft.	Juos	24.95	Artr	12.76	P	45.33
						L	49.52
						BG	4.58
						Sihi	0.19
						Phho	0.38
	2 33 ft.	Juos	14.67	Artr	4.77	P	42.94
		Pimo	22.52	Arno	8.40	L	54.58
						BG	0.00
						Sihi	1.72
						Phho	0.38
						Annuals	0.38
	3 74 ft.	Pied	45.64	Artr	8.16	P	30.61
				Arno	3.52	L	65.49
						BG	3.15
						Phho	0.19
						Sihi	0.37
						Annuals	0.19



Table 10. Continued.

Plot	Transect Number <u>1/</u>	Percent Cover				
		Tree	Shrub		Ground <u>2/</u>	
$\bar{x}$		Juos 13.21	Artr 8.56	P		39.63
		Pimo 7.51	Arno 3.97	L		56.53
		Pied 15.21		BG		2.57
				Phho		0.32
				Sihi		0.76
				Annuals		0.19
Debris Check # 2	1 19 ft.	Juos 8.02	Artr 1.68	P		67.54
			Arno 3.73	L		22.76
				BG		8.96
				Phho		0.37
				Sihi		0.37
	2 33 ft.	Juos 32.65	Artr 5.97	P		46.27
			Arno 2.24	L		40.86
				BG		12.31
				Phho		---
				Sihi		0.56
	3 74 ft.	0.00	Artr 2.24	P		76.70
			Arno 15.11	L		13.21
				BG		9.36
				Eri. spp.		0.73
	$\bar{x}$	Juos 13.56	Artr 3.30	P		63.50
			Arno 7.03	L		25.61
				BG		10.22
				Phho		0.12
				Sihi		0.31
				Eri. spp.		0.24
Debris Check # 3	1 19 ft.	0.00	Arno 8.33	P		76.55
				L		13.95
				BG		8.34
				Eri. spp.		0.97
				Phho		0.19
	2 33 ft.	Pied 11.63	Artr 4.65	P		41.28
			Arno 13.76	L		52.71
				BG		4.67
				Eri. spp.		0.38
				Annuals		0.58
				Chvi		0.19
				Sihi		0.19

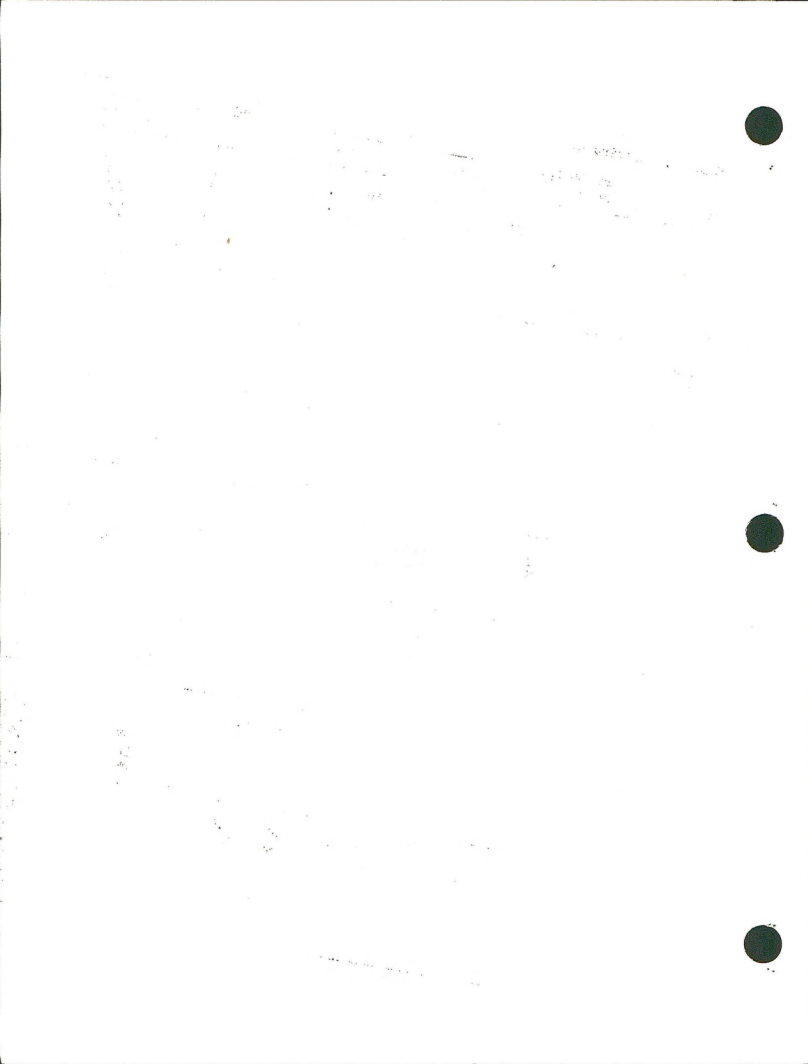


Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover					Ground ^{2/}
		Tree	Shrub				
	3 74 ft.	Juos 33.33	Artr 1.76		P 36.47 L 38.82 BG 23.93 Chvi 0.39 Annuals 0.39		
$\bar{x}$		Juos 11.11 Pied 3.88	Artr 2.15 Arno 7.36		P 51.43 L 35.16 BG 12.52 Eri. spp. 0.32 Annuals 0.32 Chvi 0.19 Sihi 0.06		
Debris Check # 4	1 19 ft.	Juos 34.78	Artr 6.13 Arno 9.88		P 37.94 L 49.21 BG 11.86 Phho 0.79 Sihi 0.20		
	2 33 ft.	Juos 24.46	Arno 2.76		P 55.03 L 40.43 BG 4.54		
	3 74 ft.	Pimo 26.10	Arno 2.39		P 50.80 L 47.01 BG 1.60 Sihi 0.20 Eri. spp. 0.39		
$\bar{x}$		Pied 8.70 Juos 19.75	Artr 2.04 Arno 5.01		P 47.92 L 45.55 BG 6.01 Phho 0.26 Sihi 0.13 Eri. spp. 0.13		
Debris Check # 5	1 19 ft.	Juos 3.67	Arno 2.32		P 55.21 L 27.99 BG 16.02 Sihi 0.39 Phho 0.39		

Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover				Ground ^{2/}
		Tree	Shrub			
	2 33 ft.	0.00	0.00		P L BG Astrag. spp. R	97.28 1.16 0.59 0.19 0.78
	3 74 ft.	Juos 16.15 Pied 14.62		0.00	P L BG Phho	50.96 42.31 6.34 0.39
$\bar{x}$		Juos 6.61 Pied 4.87	Arno	0.77	P L BG R Astrag. spp. Phho	67.82 23.82 7.78 0.26 0.06 0.26
D.I.P. # 1 ^{3/}	1 19 ft.	0.00	Artr	4.67	P L BG Agcr Phho Annuals Misc. Eri. spp.	66.54 28.22 1.51 0.56 --- 2.24 0.56 0.37
	2 33 ft.	0.00	Artr Arno	0.68 0.68	P L BG Agcr Phho Annuals	69.56 14.12 13.77 0.51 1.19 0.85
	3 74 ft.	0.00	Artr	0.54	P L BG Agcr Annuals	56.65 36.33 3.42 0.90 2.70

^{3/} Chain with debris in place plots.

1. The first part of the report is a general introduction to the subject of the study. It discusses the importance of the study and the objectives of the research. It also provides a brief overview of the methodology used in the study.

2. The second part of the report is a detailed description of the study area. It provides information about the location of the study area, the population of the area, and the characteristics of the area. It also discusses the data sources used in the study.

3. The third part of the report is a detailed description of the study results. It provides information about the findings of the study, the conclusions drawn from the findings, and the implications of the findings. It also discusses the limitations of the study.

4. The fourth part of the report is a detailed description of the study conclusions. It provides information about the overall findings of the study, the conclusions drawn from the findings, and the implications of the findings. It also discusses the limitations of the study.

5. The fifth part of the report is a detailed description of the study conclusions. It provides information about the overall findings of the study, the conclusions drawn from the findings, and the implications of the findings. It also discusses the limitations of the study.

Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover				
		Tree	Shrub		Ground ^{2/}	
$\bar{x}$		0.00	Artr	1.96	P	64.25
			Arno	0.23	L	26.22
					BG	6.23
					Phho	0.40
					Annuals	1.93
					Misc.	0.19
					Eri. spp.	0.12
D.I.P. # 2	1 19 ft.	0.00	Artr	0.40	P	73.19
					L	20.77
					BG	5.64
					Eri. spp.	---
					R	0.20
					Agcr	0.20
	2 33 ft.	0.00		0.00	P	59.26
					L	21.40
					BG	12.35
					Eri. spp.	0.82
					Lupine spp.	5.97
					Phho	0.20
	3 74 ft	0.00		0.00	P	56.49
					L	31.38
					BG	9.09
					Annuals	0.22
					Astrag. spp.	2.60
					Agcr	0.22
$\bar{x}$		0.00	Artr	0.13	P	62.98
					L	24.52
					BG	9.09
					Eri. spp.	0.27
					Lupine spp.	1.99
					Astrag. spp.	0.87
					Phho	0.07
					Agcr	0.14
					R	0.07
D.I.P. # 3	1 19 ft.	0.00	Artr	0.96	P	58.62
					L	33.72
					BG	6.13
					Agcr	0.38
					Annuals	0.96
					Eri. spp.	0.19

Table 10. Continued.

Plot	Transect Number ^{1/}	Percent Cover					
		Tree		Shrub		Ground ^{2/}	
	2 33 ft.	Pied	4.21	Artr Arno	0.96 2.11	P L BG Lupine spp. Sihi Ager Misc.	65.52 27.01 4.59 1.15 0.77 0.19 0.77
	3 74 ft.	Juos	0.57		0.00	P L BG Eri. spp. Sihi Ager Annuals	79.35 13.96 4.22 0.57 0.19 1.14 0.57
		Juos Pied	0.19 1.40	Artr Arno	0.65 0.70	P L BG Ager Annuals Eri. spp. Lupine spp. Sihi Misc.	67.83 24.90 4.95 0.57 0.51 0.25 0.38 0.32 0.29
D.I.P. # 4	1 19 ft.		0.00		0.00	P L BG Eri. spp. Lupine spp.	26.97 68.44 2.76 0.18 1.65
	2 33 ft.		0.00		0.00	P L BG Penst. spp. Misc.	21.95 52.57 22.12 2.48 0.88
	3 74 ft.		0.00		0.00	P L BG Annuals	46.02 44.55 8.94 0.49

Table 10. Continued.

Plot	Transect Number $\frac{1}{2}$	Percent Cover			
		Tree	Shrub		Ground $\frac{2}{2}$
$\bar{x}$		0.00	0.00	P L BG Eri. spp. Lupine spp. Penst. spp. Annuals Misc.	31.65 55.19 11.27 0.06 0.55 0.83 0.16 0.29
D.I.P. # 5	1 19 ft.	0.00	0.00	P L BG Agcr Annuals	30.68 64.20 4.74 0.19 0.19
	2 33 ft.	0.00	Artr 1.67	P L BG Agcr Annuals	70.37 27.04 0.36 0.56 1.67
	3 74 ft.	0.00	Arno 2.35	P L BG R Agcr Annuals	88.81 1.99 8.30 0.36 0.36 0.18
$\bar{x}$		0.00	Artr Arno 0.78	P L BG R Agcr Annuals	63.29 31.08 4.46 0.12 0.37 0.68



Appendix A

Copy of the manuscript entitled

"Influence of Pinyon-Juniper Conversions and
Water Quality on Permeability of Surface Soils"

18. 1st Regt. 1st Div. 1st Inf. 1st Bn. 1st Co. 1st Pl.

Influence of Pinyon-Juniper Conversions and Water
Quality on Permeability of Surface Soils ^{1/}

by

Gerald F. Gifford ^{2/} and Ronald K. Tew ^{3/}

INTRODUCTION

The influence that various eradication treatments for pinyon-juniper (Pinus edulis Engelm., Pinus monophylla Torr. and Frem. - Juniperus spp.) have on water yield, runoff, sediment production, soil moisture patterns, etc., is of utmost concern to watershed managers in the western United States. The majority of published papers concerning the hydrology of pinyon-juniper sites deal with rainfall interception or water yields associated with plant removal.

Pinyon-juniper is generally controlled by chaining (a large anchor chain is pulled between two tractors to fell the trees), and the debris either left where it falls or later windrowed. In conjunction with chaining, grass seed is usually broadcast or drilled, depending on how the debris is handled. During windrowing, the upper 4 inches of soil is thoroughly disturbed. Less disturbance occurs when the debris is left where it falls. It is conceivable, therefore, that the infiltration and percolation rates of surface soils might be affected by the debris-disposal treatments.

^{1/} This study conducted under cooperative agreement between U.S. Forest Service, Intermountain Forest and Range Experiment Station, and Utah State University in cooperation with the Bureau of Land Management (Contract 14-11-0008-2837).

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1. The first part of the report is a general introduction to the subject of the study.

2. The second part of the report is a detailed description of the methods used in the study.

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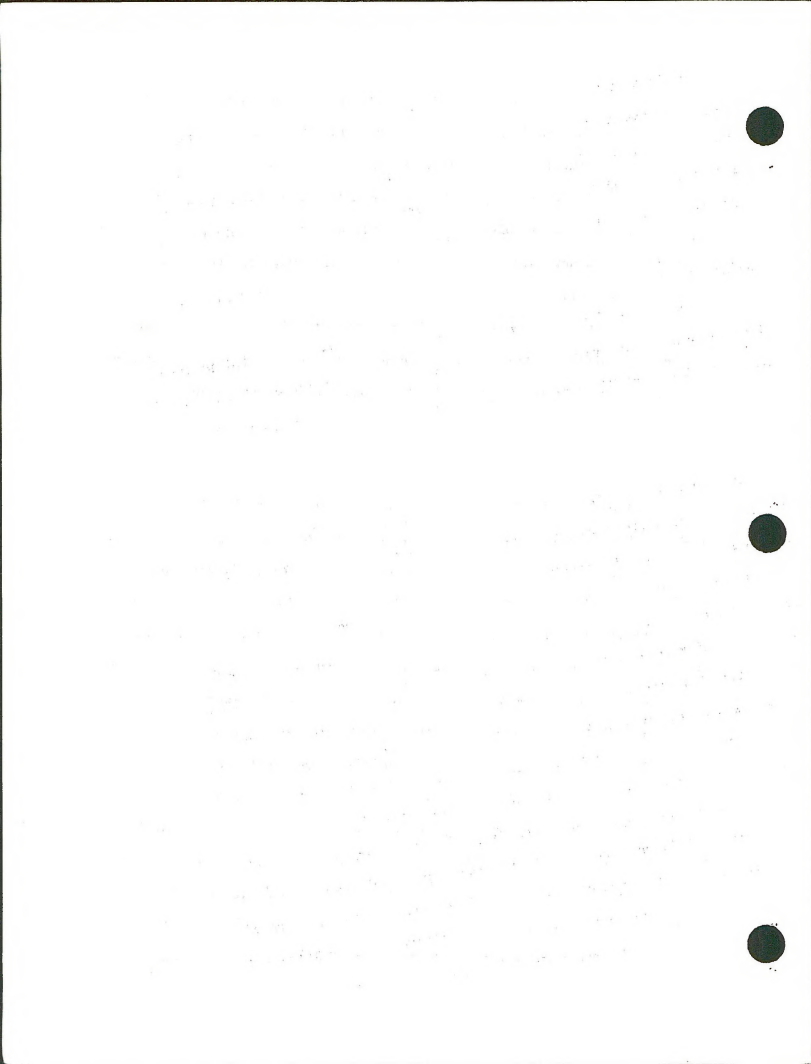
Infiltrimeters have been widely used to study the influence of land management practices on infiltration and erosion. Depending on distance between sites, natural waters of various qualities may be used to provide simulated rainfall for infiltration measurements. Final infiltration rates (governed somewhat by percolation rates) could differ significantly at a given time and location depending upon source (and, therefore, quality) of water applied as rainfall.

The objective of this study was to determine the influence that pinyon-juniper eradication treatments and water quality have on percolation rates of southern Utah rangeland surface soils disturbed less than one year ago.

METHODS

Two sites were studied, one in southeastern Utah near Blanding and the other in southwestern Utah near Milford. Pinyon and juniper were the dominant vegetation types present on both sites. Surface soils varied from a sandy loam (sandstone-siltstone parent material, 0.2 to 1.1% rock > 2 mm diameter) at the Blanding site to a silt loam (basalt parent material, 18.4 to 31.6% rock > 2 mm diameter) at the Milford site. At each site were the following treatments: (1) pinyon-juniper chained and windrowed, (2) pinyon-juniper chained with debris left in place, and (3) undisturbed pinyon-juniper. Chaining treatments were applied during November, 1967 to a minimum of 30 acres, crested wheatgrass was seeded, and the areas were fenced.

Soil samples were collected during May, 1968 at the 0-2 and 2-4 inch depth intervals at 30 grid points on each 30-acre plot. Samples from three points were then randomly selected and composited until 10 replications of composited samples were obtained for each depth interval. The samples were taken to the laboratory, passed through a 2 mm sieve, and stored until analyzed.



Soil texture was determined by hydrometer method (Bouyoucos, 1962).

Organic matter content was determined by a wet oxidation method (Schollenberger, 1945). Aggregation, particle density, porosity, and pH were determined by methods outlined by Richards (1954). The procedure given by Reeve (1965) was used for permeability measurements. Only 6 of the 10 replications of the soil samples collected were used for the permeability measurements.

Three different qualities of water were used for permeability tests on each soil sample: (1) distilled water, (2) tap water obtained at Milford, and (3) tap water obtained at Blanding. The quality of the waters (see Table 1) including pH, conductivity and the content of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride and sulfate was determined by methods of analysis given by Richards (1954).

The soils were prepared for permeability studies by dumping each sample into a 3-ounce can which had a wire screen and a filter paper covering the bottom. Each can had a small hole punched in the bottom for drainage and a cylinder extension placed at the top. The soil was packed by dropping the container from a height of 2.5 cm 200 times on a wooden block. The cylinder extension was removed and the soil leveled to the top of the can. The same packing procedure was used to obtain bulk density values used in porosity calculations. After the soils were leveled in the cans, the cylinder extension was replaced and sealed to the can with rubber cement. The sample was then placed on a rack where water was admitted to the sample from a supply tank having a constant head. The quantity of water percolating through the soil was measured at 5-minute intervals for a total of 45 minutes.

Soil permeability was calculated using the equation and symbols given by Reeve (1965) where:

$$k_w = \frac{N}{P_w g} \frac{VL}{A \Delta h \Delta t}$$

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Table 1. Quality of waters used for percolation study (excluding distilled water).

Quality Measured	Source of Water	
	Blanding	Milford
ECX 10^5	18	45
pH	8.15	8.36
Ca (ppm)	25	14
Mg (ppm)	5	4.8
Na (ppm)	4	63
K (ppm)	0.8	3.2
CO ₃	none	none
HCO ₃ (ppm)	176.3	104.6
SO ₄ (ppm)	11.0	37.4
Cl (ppm)	0.50	35.5

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in which:

K_w = intrinsic permeability with water, cm^2

N = water viscosity, poises

P_w = water density, g/cm^3

g = acceleration of gravity, cm/sec^2

V = volume of percolate in time t , cm^3

L = length of soil column, cm

Δh = difference in hydraulic head between inflow and outflow, cm

A = cross sectional area of soil column, cm^2

Δt = time interval involved, sec .

RESULTS

Analysis of variance of intrinsic permeabilities after 45 minutes and also volume of water percolated through the soil columns after each 5-minute interval revealed significant interactions among site x treatment, site x depth, and treatment x soil depth. Quality of water did not significantly affect percolation rates the first half hour, but was a significant factor thereafter.

At the Milford site, treatment significantly influenced intrinsic permeability of the soil columns (Table 2). Pooled over both depths and three waters, mean intrinsic permeability of surface soils from the chain and windrow treatment was 1.13 cm^2 compared with 0.84 cm^2 and 0.54 cm^2 for chaining with debris in place and control treatments, respectively. The trend was the same at the Blanding site but differences among treatments were not significant at the .05 level of probability.

In addition, at the Milford site, intrinsic permeability values of soil samples from the 2-4 inch depth were significantly greater than those from the 0-2 inch depth (Table 3). Pooled over three treatments and three waters,

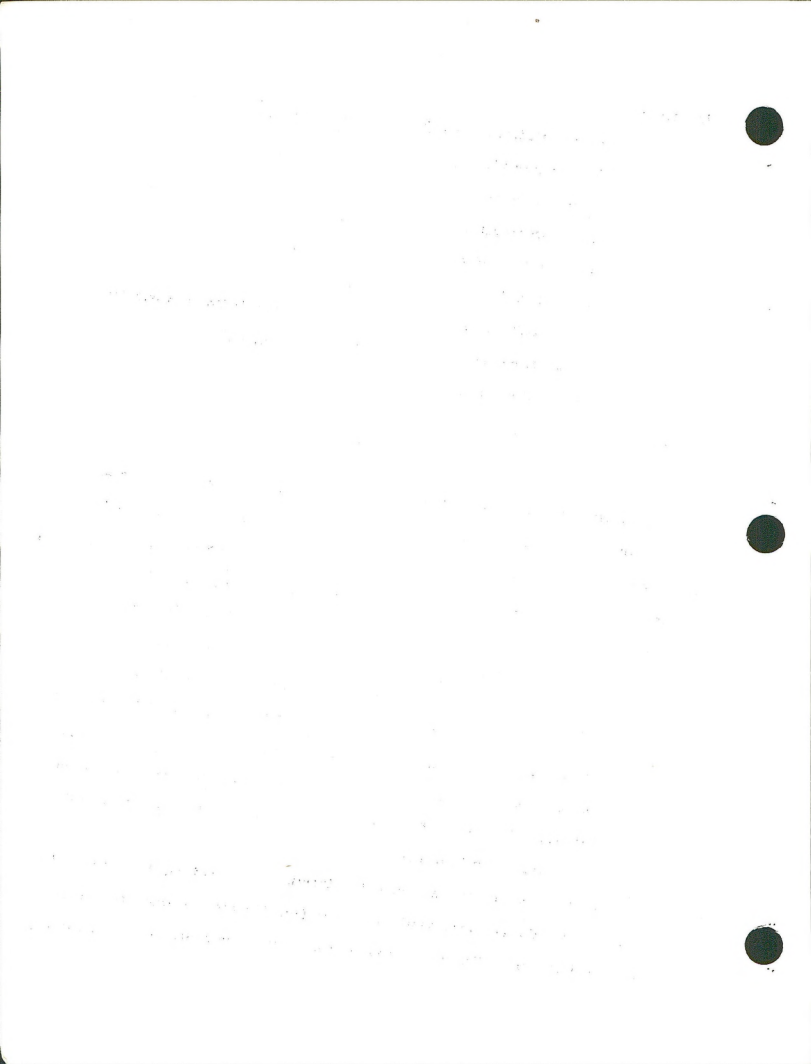


Table 2. Influence of pinyon-juniper treatment on intrinsic permeability (cm^2) of soil columns after 45 minutes (two sites).

Site	Treatment ^{1/}		
	Chain, windrow	Chain, debris in place	Control
Blanding	1.00 ^a	0.80 ^a	0.76 ^a
Milford	1.13 ^b	0.84 ^a	0.54 ^a

^{1/} Any two means in same row with same letter are not significantly different at .05 level of probability (Duncan's multiple range test). Means represent two depths, three waters, and six replications.

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additional data and figures.

Table 3. Influence of depth from which soil sample was collected on intrinsic permeability (cm^2) after 45 minutes (two sites).

Site	Soil depth (inches) ^{1/}	
	0-2	2-4
Blanding	0.71 ^a	1.00 ^a
Milford	0.40 ^a	1.28 ^b

^{1/} Any two means in same row with same letter are not significantly different at .05 level of probability (Duncan's multiple range test). Means represent three treatments, three waters, and six replications.

mean intrinsic permeability was 3.2 times greater in soil from the 2-4 inch depth than in soil from the 0-2 inch depth. For soil from the Blanding site, mean intrinsic permeability was 1.4 times greater at the 2-4 inch depth than at the 0-2 inch depth. Differences at the Blanding site were not significant.

The chain and windrow treatment significantly influenced intrinsic permeability at the 2-4 inch depth (Table 4). There were no significant differences between control and chaining with debris in place at the 2-4 inch depth, nor were there significant differences among any treatments with respect to intrinsic permeability of soil from the 0-2 inch depth. The trend, however, was toward increased permeability with the chain and windrow treatment.

As mentioned above, water quality influenced volume of percolate only after 30 minutes. Since intrinsic permeabilities were calculated after 45 minutes, water quality was a significant factor. Pooled over two sites, three treatments, and two soil depths, mean intrinsic permeability for distilled water was 0.78 cm^2 , for Milford water 0.88 cm^2 , and for Blanding water 0.87 cm^2 . Intrinsic permeabilities for Milford and Blanding waters were not significantly different at the .05 level of probability.

Factors Influencing Permeabilities

Parameters associated with each soil column were measured to determine their influence on percolation rates and intrinsic permeabilities for each of the three waters. The parameters included soil texture (sand, silt, clay, silt plus clay, % rock > 2 mm diameter originally in sample), % aggregation, % organic matter, pH, bulk density, particle density, and % total porosity. Soil factors important for predicting percolated volumes after each 5-minute interval did not change significantly with time, so only factors important in predicting intrinsic permeabilities after 45 minutes are considered here.

Three multiple regression equations were derived for predicting intrinsic

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Table 4. Influence of pinyon-juniper treatment on intrinsic permeability (cm^2) after 45 minutes (two soil depths).

Depth (inches)	Treatment ^{1/}		
	Chain, windrow	Chain, debris in place	Control
0-2	0.72 ^a	0.50 ^a	0.44 ^a
2-4	1.41 ^b	1.14 ^a	0.87 ^a

^{1/} Any two means in same row with same letter are not significantly different at .05 level of probability (Duncan's multiple range test). Means represent two sites, three waters, and six replications.

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3. The third part of the report deals with the conclusions and recommendations. It is divided into two main sections: the first section deals with the conclusions, and the second section deals with the recommendations.

4. The fourth part of the report deals with the appendix. It is divided into two main sections: the first section deals with the list of names, and the second section deals with the list of places.

permeabilities (k_w , cm^2) after 45 minutes at either the 0-2 or 2-4 inch soil depth at either site, one equation for each of the three waters:

Distilled water

$$Y = -2.654 - .087 (\% \text{ organic matter}) + .090 (\% \text{ total porosity}) \\ - .011 (\% \text{ silt plus clay}) \quad R^2 = 0.56 \quad (R = .75)$$

Milford water

$$Y = -15.362 + 3.796 (\text{bulk density, g/cc}) + .026 (\% \text{ sand}) + \\ .195 (\% \text{ total porosity}) + .041 (\% \text{ clay}) \quad R^2 = 0.65 \quad (R = .81)$$

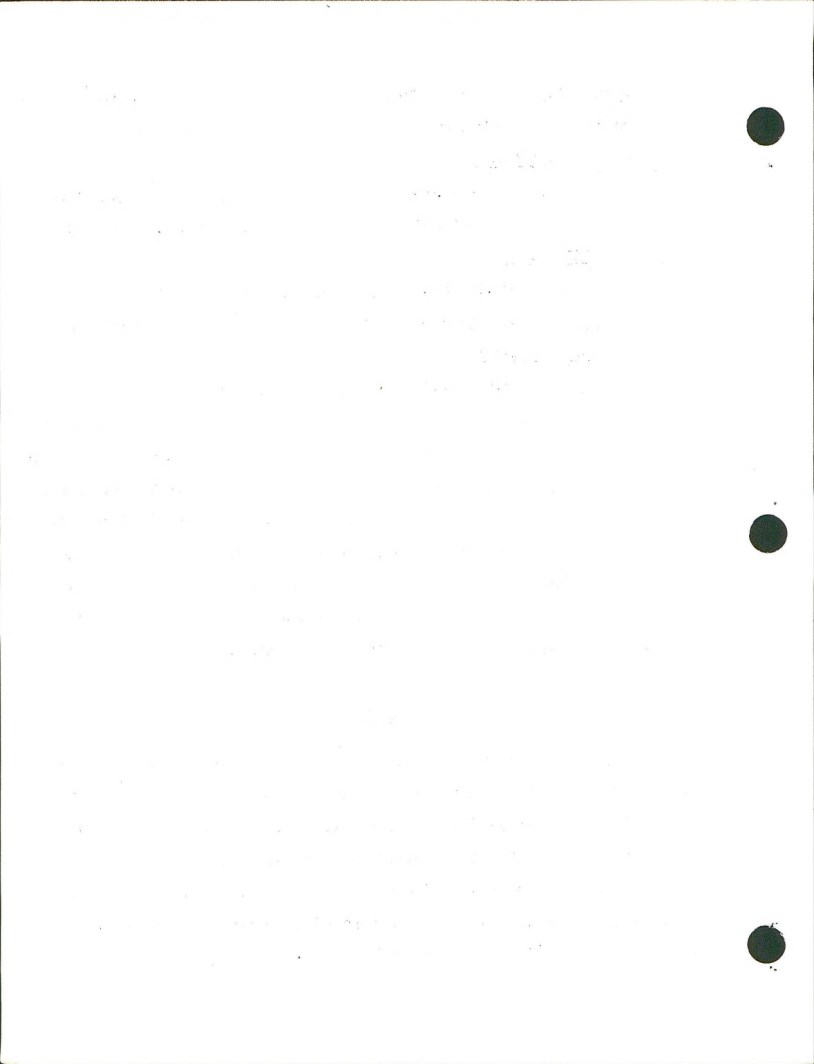
Blanding water

$$Y = -8.527 + 4.986 (\text{particle density, g/cc}) + .027 (\% \text{ sand}) \\ -3.893 (\text{bulk density, g/cc}) + .037 (\% \text{ clay}) \quad R^2 = 0.64 \quad (R = .80)$$

It is obvious that the optimum equation for each water contains factors which differ from the other two. Percent total porosity explained 45 and 58% of the variation associated with intrinsic permeabilities measured with distilled and Milford waters, respectively. The remaining variables explained from one to six percent of the variation. With Blanding water, bulk density explained 45% of the variation associated with intrinsic permeabilities while the remaining variables explained from 1 to 12% of the variation.

DISCUSSION

Permeability of surface soils on pinyon-juniper sites is an important hydrologic variable. This factor is particularly important on sites where soil surface protective cover (canopy cover, litter, erosion pavement) is sufficient to allow potentially high infiltration rates. Vegetative manipulation treatments which enhance surface soil permeability, and at the same time maintain or increase protective soil cover, should be encouraged where economically (or otherwise) feasible.



Results of this study indicate that chaining of pinyon-juniper does increase permeability of the 0-2 and 2-4 inch surface soil depths during the first year following treatment. The chaining with windrowing treatment was particularly effective in this respect. Mechanical soil disturbance associated with this treatment probably increases noncapillary porosity through decreased bulk densities and incorporation of litter into the surface soils. Such relationships are shown in Figure 1 for the Milford (Basin and Range Province) site.

Permeability of soil from the 0-2 inch depth was less than that from the 2-4 inch depth, regardless of treatment. A greater aggregation percentage in the 2-4 inch depth, especially at the Milford site, may partially account for the observed differences.

Percolation rates were not influenced by the qualities of water in this study during the first 30 minutes of each percolation trial. Therefore, to the extent that percolation governs infiltration, no bias resulting from water quality should arise if infiltrometer runs on these sites are held to 30 minutes or less.

Effect of percolation on infiltration rates at these sites should increase as seeded species become established. During the time when chained and windrowed pinyon-juniper sites lack soil protective cover, surface conditions such as raindrop compaction and aggregate breakdown plus clogging of soil pores will result in increased overland flow and greater sediment production than control (or undisturbed) areas which still support some protective vegetative canopy (Gifford, unpublished data). In other words, increased soil permeability is no asset if water is unable to enter the soil surface.

Regression equations for predicting intrinsic permeability of soil columns varied according to the quality of water. This type of variation may influence regression equations used for predicting infiltration rates on semiarid range-land sites, especially if various qualities of water are used during infiltration measurements.

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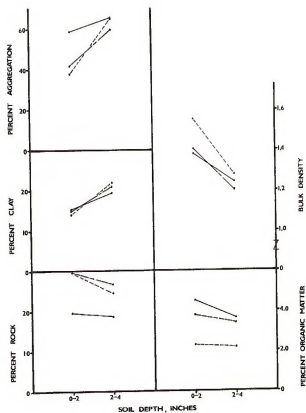


Figure 1. Characteristics of soils under three pinyon-juniper eradication treatments at the Milford, Utah site. Dotted line represents untreated; broken line represents chaining with debris in place; solid line represents chain and windrow treatment.

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Abstract. Permeability of surface soils from the 0-2 and 2-4 inch depths at each of two sites in the pinyon-juniper type of southeastern and southwestern Utah were studied using disturbed soil samples. Three recent vegetation manipulation practices (chaining and windrowing, double chaining with debris left in place, and undisturbed) and three qualities of water were studied in this respect. The chaining with windrowing treatment significantly increased permeability of surface soils from southwestern Utah. Significant differences in permeability were lacking between soils from double chaining with debris in place and undisturbed treatments. Permeability of surface soils from southeastern Utah provided a similar trend, though significant differences among treatments were not evident.

Water quality influenced percolation only after approximately 30 minutes. Multiple regression equations developed for predicting intrinsic permeabilities varied according to quality of water.

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